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Seasonal influences on the rooting response of Chir pine (*Pinus roxburghii* Sarg.)

S.K. Sharma, S.K. Verma

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Abstract. Rooting ability of the vegetative cutting depends upon the various factors: age, size, and diameter of cutting, season, rooting substrate and concentration of the applied growth hormone. For assessing the seasonal variation in rooting ability of shoot, cuttings were taken from 4 year old hedges. Shoot cuttings were collected after every two months of hedging spring (March), summer (June), autumn (September) and winter (December) and treated with 4000 ppm Indole Butyric Acid (IBA), mixed with talc powder and planted in vermiculite filled beds. Suitable control was also maintained, wherein only talc powder was applied to the basal portion of cuttings. Periodical observations were taken on cuttings, with regard to root initiation. The cuttings were uprooted after 12 weeks of planting and observations were recorded. Highly significant differences were observed between root length, shoot length, number of roots per cutting and rooting percentage. This has led to the evaluation of a standard technique for application of mass clonal propagation of Chir pine during summer season (June), which would result into a good success in rooting percentage. This technique could also be helpful in the establishment of germplasm banks of desired genotypes and Clonal Seed Orchards (CSOs). Further, this will also help in overcoming the problem of stock and scion incompatibility, which is commonly faced, when Clonal Seed Orchards are established through grafted material.
Keywords seasonal variation, rooting ability, Chir pine, vegetative multiplication Garden (VMG), Clonal Seed Orchard (CSO).

Author. S.K. Sharma (sharmasati@gmail.com) - SLEM Project, Directorate of Extension Indian Council of Forestry Research & Education, Dehradun, S.K. Verma - 2. College of Hort. & Forestry, Kumarganj, Faizabad, PIN-224 229 (UP), India.

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Introduction

Pinus roxburghii is the most important and extensively used species of afforestation programmes in the subtropical Himalayan and Shiwalik regions. *Pinus* is found from East to west of Nepal, but only difference is that in western part, mainly pure pine forest is found whereas in eastern part, mixed pine forest is found (Jackson 1994). A huge quantity of Chir pine seed is required every year to meet the target of afforestation programme, which becomes very difficult, particularly during poor seed years, however, a good seed year may be expected only after 3 to 4 years. In such conditions, the vegetative propagation could serve as an alternative method to produce viable and uniform planting stock and therefore helpful to supplement the deficit. Vegetative propagation also allows greater genetic gain of desired trait straightness of bole, branching characteristic, large volume and high resin yield, which are being examined for tree improvement of Chir pine and other conifers.

In Nepal, Ministry of Forest and Soil Conservation has also focused *Pinus roxburghii* as commercially planted species for commercial forest plantation (Amatya 2002). There, *Pinus roxburghii* plantation is considered the most appropriate project for both GHS emission reduction project and livelihood promotion project for maximum utilization of the clean development mechanism CDM fund.

Vegetative propagation (macropropagation) under mist conditions is a quick and economically useful technique for producing true to the parent type and uniform planting material of superior quality (Thatoi et al. 2000) under forestry programme in the present scenario. By means of this technique, promising genotypes can be multiplied. The use of growth hormones and vitamins, as accelerators of rooting of various conifers, are now extensively used in afforestation programme and in the establishment of Clonal Seed Orchards (CSOs) (Clarke & Slee 1984, Armson et al. 1980, Hare 1978). Auxins, along with phenols and chemicals like captan, sucrose and growth retardants are known to stimulate root initiation in cuttings of pines and other conifers (Grigsby 1966, Lahiri 1979, Hare 1974, Haissig 1974, Samet & Khosla 1996). Indian pines, including *Pinus roxburghii* Sarg. are considered most difficult species to root by branch cuttings. Attempts made in the past to root branch cuttings of *Pinus roxburghii* have failed. Bhatnagar (1977) reported 30% rooting in Chir pine in 50 ppm IBA solution. Recently, Joshi and Dhiman (1992) and Uniyal et al. (2001) have reported multiplication of Indian Chir pine through shoot cuttings in the mist conditions.

Hedging or stumping, is an important stock plant management technique that maintains juvenility, allows for increased shoot production, allows for easier cutting collection, and reduces sexual reproduction (Hartmann et al. 2002). Previous research with Fraser fir (Wise et al. 1985), loblolly pine (*Pinus taeda*)(Cooney 1999), radiata pine (*Pinus radiata*)(Bolstad & Libby 1982, Fielding 1954, Libby et al. 1972), Douglas-fir (*Pseudotsuga menziesii* Mirb. Franco)(Black 1972) and Norway spruce (*Picea abies* L.)(Bentzer 1993) has demonstrated that continuous hedging of a stock plant provides a way to increase cutting production and maintain juvenility.

The present study was done with the aim to find out seasonal fluctuation in the rooting behaviour of Chir pine.

Materials and methods

Juvenile shoots of Chir pine were collected from 4-year-old plants, every two months following hedging in four seasons viz., spring (March, 2000), summer (June, 2000), autumn (September, 2000) and winter (December, 2000) from Vegetative Multiplication Garden (VMG). This VMG was established at New Forest Campus, Dehradun (640 m alt., lat. $30^0 20'40''$ N, long. $77^0 52'12''$ E and Rainfall 216 cm). This VMG comprises 26 superior phenotypes from Uttaranchal, UPTSB-14, UPBER-5, UPKAL-10, UPPAT-1094, UPTSS-3, UPDNH-770, UPBER-368, UPDNH-81, UPTNM-1, UPTSB-8, UPJAR-541, UPJAR-745, UPSON-23, UPTSN-5, UPSON-21, UPKAR-1148, UPDNR-171, UPKAL-5, UPDNH-720, UPPAT-1080, UPSON-24, Himachal Pradesh viz., HPSNR-3, HPSNR-4 HPSNR-5 and Jammu & Kashmir viz., JKKAT-10 and JKRAJ-4. From these 26 phenotypes, 9 outstanding phenotypes (based on their growth and coppicing pattern) were selected for the study viz., UPTSB-14 (Bhasla, U. A.), HPSNR-5 (Nurpur, H.P.), UPBER-5 (Berinag, U.A.), UPKAL-10 (Kaligadh, U.A.), UPPAT-1094 (Patwadanger, U.A.), UPTSS-3 (Sikanderdhar, U.A), UPDNH-770 (Dhanari, U.A.), UPBER-368 (Berinag, U.A.), and UPDNH-81(Dhanari U.A.). Shoot cuttings measuring 5-7 cm in length and 2 to 4 mm in diameter were prepared from the collected shoots without damaging the shoot, apexes. Wherein 10 cuttings per treatment in 3 replicates from 9 sources in 4 seasons and 2 treatments, i.e. 10 x 3 x 9 x 4 x 2 = 2160 cuttings in all were treated with 4000 ppm Indole Butyric Acid (IBA), mixed with talc powder and planted in vermiculite filled beds in the mist chamber of Central Nursery, FRI, Dehra Dun. Suitable control was also maintained, wherein only talc powder was applied to the basal portion of cuttings. The experiment was laid out in a complete randomized design (CRD). During the experiment, the cuttings were given intermittent misting.

Periodical observations were taken on cuttings with regard to root initiation. The cuttings were uprooted from the vermiculite beds after 12 weeks of planting and the observations were recorded for shoot length and various other root parameters: rooting percent, root length, and number of roots per cutting.

The data were subjected to statistical analysis (ANOVA), to find out the significance of differences observed. Wherever, data were recorded as percentage the arcsin transformed values were used for statistical analysis.

Results

Maximum root length 11.0 cm, followed by 10.4 cm in HPSNR-5 source was recorded during spring (March) and summer (June) minimum 2.5 cm in UPTSB-14 during spring (March) season in control treatment (Table 1). Maximum shoot length 13.3 cm followed by 12.1 cm was registered in UPBER-5 and UPKAL-10 during summer (June), while minimum 5.5 cm followed by 6.5 cm during winter (December) (Table 1). Similarly, maximum number of roots per cuttings 3.6 followed by 3.5 were recorded in UPTSB-14 and HPSNR-5 during summer (June) season and minimum 1 was recorded in UPPAT-1094 during spring (March) and also in UPKAL-10, UPTSS-3, UPBER-368 during summer (June), these all were noticed in control treatment (Table 2). So far, the best season of rooting is concerned, the highest percentage of success in rooting (100%) was exhibited by UPPAT-1094, UPTSB-14, and UPKAL-10 sources during summer (June). No rooting could be achieved under control, when cuttings were planted during autumn and winter season with the exception of one source viz. UPPAT-1094 (Table 2) wherein 10% success in rooting was observed when cuttings were planted in autumn (September). Physiologically speaking, two seasons autumn (September) and winter (December) remained inactive, while spring (March) and summer (June) seasons were highly active seasons. As far as best phenotype is concerned, one of the phenotypes (UPPAT-1094) showed its supremacy over others regarding rooting, which responded positive behaviour throughout the year except in the control treatment of winter (December) season. On the other hand one of the sources UPBER-5 responded negative altogether in control treatment through out the year (in all the seasons), while all the phenotypes responded positive and remained active in 4000 ppm IBA concentration during spring (March) and summer (June) seasons. Statistical analysis of data has revealed highly significant differences for all the parameters. The Critical Difference (CD) was found to be 2.388 for mean root length, 2.797 for mean shoot length, 0.731 for mean number of roots per cutting and 7.330 for rooting percentage (Tables 1, 2).

Table 1 Variation in mean length of root (cm) and mean length of shoot (cm) in the rooted cuttings of Chir pine (*Pinus roxburghii*) under four different seasons

Source	Mean length of root (cm)								Mean length of shoot (cm)							
	Spring (March)		Summer (June)		Autumn (September)		Winter (December)		Spring (March)		Summer (June)		Autumn (September)		Winter (December)	
	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B
UPPAT-1094	8.63	3.5	8.50	9.00	5.5	4.0	5.0	0	10.17	9.5	10.9	7.5	9.5	7.0	5.5	0
UPTSB-14	9.00	2.5	9.50	3.50	6.5	0.0	0.0	0	10.33	9.5	12.0	7.0	10.0	0.0	0.0	0
UPKAL-10	9.42	4.5	8.10	5.50	0.0	0.0	0.0	0	10.58	9.0	12.1	8.0	0.0	0.0	0.0	0
UPBER-5	8.30	0.0	10.10	0.00	0.0	0.0	0.0	0	9.70	0.0	13.3	0.0	0.0	0.0	0.0	0
UPTSS-3	9.30	4.0	8.37	0.00	6.0	0.0	0.0	0	10.20	9.5	10.8	0.0	10.0	0.0	0.0	0
UPDNH-770	6.70	0.0	8.00	8.75	7.5	0.0	0.0	0	9.90	0	10.4	7.5	10.5	0.0	0.0	0
UPBER-368	6.50	0.0	7.00	6.50	5.0	0.0	4.5	0	9.50	0.0	12.0	7.5	11.0	0.0	6.5	0
UPDNH-81	7.33	4.5	9.75	8.00	0.0	0.0	0.0	0	9.50	9.0	10.5	6.0	0.0	0.0	0.0	0
HPSNR-5	11.00	0.0	10.40	6.00	4.5	0.0	0.0	0	9.75	0.0	12.0	7.5	9.5	0.0	0.0	0
CD	2.388								2.797							
Sig. Level	***								***							

Note: A - 4000 ppm IBA, B - Control, significance at 0.01% level of probability

Discussion

Thatoi et al. (2000) reported that the root hormones like IAA, IBA and NAA were found to be effective than commercial rooting powders like Rootex and Keradix for inducing rooting in stem cuttings of two species viz. *Cerbera manghas* and *Merope angulata*. It was observed that both the species showed delayed rooting response, commercial rooting powders did not induce any rooting response in either of the species. Gupta and Chandra (1979) reported that soft woodcuttings were helpful in producing roots quickly because the cells in butt end were still young in multiplication stage. They had less quantity of resin. Isikawa (1968) reported that as the donor plant matures not only rooting potential decreases but time taken to develop root increases and quality of root system changes (Libby & Hood 1976). Kwon et al. (1987) reported that any *Picea abies* plants <2 year old showed excellent rooting ability (min. 92%) and cuttings taken from 2 year old seedlings also had good rooting ability 97% in *Picea abies*, 84% in *Quercus acutissima* and 98% in *Betula platyphylla.* 12 week-old juvenile cuttings of *Pinus rigida* x *P. taeda* showed 84% rooting. Uniyal et al. (2001) observed significant differences in rooting response and other root parameters of the juvenile cuttings of *Pinus roxburghii* emanating from new superior clones and among various concentration of IBA tested, 4000 ppm IBA concentration was found to be the best. Doran et al. (1940) described that cuttings of white pine (*Pinus strobus* L.) which were taken from lower part of a trees in late winter, and given a relatively short treatment with a solution Indole Butyric Acid in a relatively high concentration, rooted fairly well.

Kleinschmit and Schmidt (1977) reported that significant genetic difference in root for-

Table 2 Effect of seasonal variation on mean number of roots per cutting and rooting percentage (%) in the rooted cuttings of Chir pine (*Pinus roxburghii*)

Source	Mean number of roots per cutting								Rooting percentage (%)							
	Spring (March)		Summer (June)		Autumn (September)		Winter (December)		Spring (March)		Summer (June)		Autumn (September)		Winter (December)	
	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B
UPPAT-1094	1.83	1.0	2.80	3.0	3.0	2.0	2.0	0	60	10	100	20	10	10	10	0
UPTSB-14	2.00	2.0	3.60	2.0	2.0	0.0	0.0	0	60	10	100	20	10	0	0	0
UPKAL-10	2.50	2.0	3.00	1.0	0.0	0.0	0.0	0	60	10	100	20	0	0	0	0
UPBER-5	2.20	0.0	2.77	0.0	0.0	0.0	0.0	0	50	0	80	0	0	0	0	0
UPTSS-3	2.20	2.0	1.75	1.0	2.0	0.0	0.0	0	50	10	80	0	10	0	0	0
UPDNH-770	1.80	0.0	1.75	2.0	2.0	0.0	0.0	0	50	0	80	40	10	0	0	0
UPBER-368	1.75	0.0	2.33	1.0	2.0	0.0	2.0	0	40	0	60	20	10	0	10	0
UPDNH-81	1.67	2.0	3.50	2.0	0.0	0.0	0.0	0	30	10	80	20	0	0	0	0
HPSNR-5	2.00	0.0	3.50	2.0	3.0	0.0	0.0	0	40	0	80	20	10	0	0	0
CD	0.731								7.330							
Sig. Level	***								***							

Note: A - 4000 ppm IBA, B - Control, significance at 0.01% level of probability

mation between the different clones while working on Norway spruce (*Picea abies*). Dorman (1947b) vegetatively propagated long leaf pine (*Pinus paulustris*) and suggested it will be possible to multiply and perpetuate material from trees showing exceptionally high yield. It will also be possible to compare under uniform conditions, gum yields of cuttings obtained from widely scattered high yielding trees. Mirov (1944), suggested that the time of year, physiological condition of the shoots, temperature of the rooting medium, and even more important, relations between the temperature of the atmosphere and that of the rooting medium, as well as many other conditions, are very important in rooting of cuttings. A proper combination of these are far more important for striking roots than the action of, say, Indole Butyric Acid alone. When all are optimum, Indole butyric acid or any similar compound might exert some beneficial influence on the cuttings, causing development of more numerous roots or earlier strikes. But when the environment is not optimum, treatment with hormone like stimulants is apparently of no avail.

The present attempt was made to demonstrate the scope for mass clonal propagation through rooting of cuttings in Chir pine (*Pinus roxburghii*) during summer season (June), which would result, into a good success in rooting percentage. Further, by manipulating the substrate enhancement in rooting percentage can be explored. This technique could also be helpful in the establishment of germplasm banks of desired genotypes and Clonal Seed Orchards (CSOs). Further this will also help in overcoming the problem of stock and scion incompatibility, which is commonly faced when

Clonal Seed Orchards are established through grafting.

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